



center for streamside studies

**10th**

**Annual**

**Review**

**abstracts**

**January 20, 2000**

**HUB West Ballroom  
University of Washington  
Seattle Wa**



# Agenda

8:30 Opening remarks (Susan Bolton)

Session I      Pete Bisson                      Moderator

8:45 Controls on Conifer Regeneration in Managed Riparian Forests: Effects of Seed Source, Substrate, and Vegetation (Eric Beach)

9:00 The Distribution of Conifers and Red Alder in Riparian Zones: Role of Soils and Other Factors (Kerri Mikkelsen and Bob Edmonds)

9:15 The Role of Red Alder in Streams: Time to Allow the Villain Back into the Fold? (Rick Edwards, Bob Edmonds and Peter Kiffney)

9:30 The 303(d) List: Are Eastern Washington's Streams in Hot Water? (Jenna Scholz)

9:45 Regional, Synchronous Field Determination of Summertime Stream Temperatures in Western Washington (Derek Booth)

10:00 BREAK              POSTER SESSION

Session II      Loveday Conquest                      Moderator

10:15 Long Term Monitoring of Riparian Buffers Using Low Altitude Fixed-Base Aerial Photography (Richard Grotefendt)

10:30 A Comparison of Methods for Measuring Water Clarity (Ashley Steel)

10:45 Patterns of Gravel Entrainment in Puget Lowland Streams (Chris Konrad)

11:00 Debris Flows and Salmon Habitat in Coastal Oregon and Washington (Dave Montgomery)

11:15 Land-use Effects on Suspended Sediment in Puget Lowland Salmonid Streams (James Packman)

11:30 Distribution and Reactivity of Dissolved Organic Matter in Subsurface Waters of a Pacific Northwest Floodplain River (Sandra Clinton)

11:45 LUNCH BREAK POSTER SESSION (dessert provided)

Session III      Derek Booth                      Moderator

1:15 Nutrient Dynamics in an Alaskan Stream: What Role do Salmon Play? (Tom O'Keefe and Rick Edwards)

1:30 Body Size, Arrival Date, and Reproductive Success of Pink Salmon, *Oncorhynchus gorboscha* (Bobette Dickerson)

1:45 Consumption Choice by Bears Feeding on Salmon (Scott Gende, Thomas Quinn and Mary Willson)

2:00 Understanding Diversity Among Participants in the Copper River Personal-Use Fishery (Amber Kocsis)

2:15 Salmon and \$\$\$ in Washington State: Factors Influencing the Distribution of Restoration Dollars (David Landsman)

2:30 BREAK              POSTER SESSION

Session IV     Mike Brett                     Moderator

- 2:45 Geomorphic Effects of Log Jams in Large Rivers: Past and Present (Tim Abbe)
- 3:00 Ecological Risk Assessment: Status of the Science (Jody Brauner)
- 3:15 A Comparison of the Hydraulic Effect of Large Woody Debris and an Engineered Wood Alternative in Western Washington Streams (Anne Watts Savery)
- 3:30 A Biological Evaluation of Stream Rehabilitation: Comparison of the Effects of Large Woody Debris and an Engineered Alternative (Jen O'Neal)
- 3:45 Historic Fire Frequency Comparisons Between Riparian Zones and Upslope Forests in the Blue Mountains and Western Cascades of Oregon (Diana Olson)
- 4:00 Closing Remarks (Susan Bolton)

## Posters

- Summer Temperatures in Small Timberland Stream Sources on the Western Olympic Peninsula (Jenelle Black)
- Controls on Hyporheic Invertebrate Biodiversity and Community Structure on the Queets River, Olympic Peninsula, WA (Holly Coe)
- Collaborative Design of Fish Habitat Enhancement Projects in Streams and Rivers of Washington State (Jim Dooley)
- In-Stream Wood in Old-Growth Forest Drainages: A Characterization Considering Geomorphic Variation (Martin Fox)
- Fertilization of Riparian Vegetation by Spawning Salmon: Effects on Tree Growth and Implications for System Productivity (Jim Helfield and Robert Naiman)
- Evaluating the Performance of a Pilot-Scale Constructed Wetland Treating Municipal Effluent: A Three Angled Approach (Lenore Jensen)
- A Comparison of Historic and Current Riparian Forest Condition in Eastern Washington and Effects on Stream Temperature (Gardner Johnston)
- Wood Distribution in Unmanaged Streams: A Diagnostic Approach Based on Geomorphic Variation (Emily Lang and Loveday Conquest)
- Effects of Timber Harvest Activities on the Distribution and Genetic Heterozygosity of Coastal Cutthroat Trout (Joshua Latterell)
- A Preliminary Examination of the Controls on Small Headwater Channel Morphology and Habitat Influence in Managed Forests (Mike Liquori)
- Trophic Relations Between Coho Salmon Carcasses, Oomycetes (Water Molds) and Select Caddisfly Larvae (Graham Mackenzie)
- Long-term Hydrologic Record of a Small Watershed in the Hoh River Valley (Georgia Murray, Bob Edmonds and Bill Baccus)
- Center for Streamside Studies and U.S.Forest Service On-Line Riparian Bibliography (Barbara Nightingale)

## **Controls on conifer regeneration in managed riparian forests: Effects of seed source, substrate, and vegetation**

Eric Beach

Factors influencing conifer regeneration in red alder (*Alnus rubra*) dominated riparian areas on managed forests were investigated using a paired site study design. The study areas were located in the foothills of the Washington Cascades and in the coastal fog belt of southwestern Washington. Densities of conifer regeneration in alder dominated riparian areas were assessed along transects adjacent to remnant patches of mature conifers and compared to transects in the same alder dominated stand established >100m from the residual stand. The results suggest that conifer regeneration rates in managed forest riparian areas are controlled primarily by the availability of shade tolerant conifer seed. Riparian areas in close proximity to mature (>60 years) forest patches containing shade tolerant species had significantly higher rates of conifer regeneration than areas without such seed sources (e.g. areas dominated by cultivated stands of Douglas-fir (*Pseudotsuga menziesii*) in the adjacent upland forest). In areas close to mature seed trees, shade tolerant species including western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*) and western red cedar (*Thuja plicata*) were able to continually establish under a deciduous overstory. Provided a source of seed was present, rooting substrates and understory vegetation were found to significantly alter the patterns and rates of regeneration. Coarse woody debris and mineral soil substrates were positively associated with regeneration success, while seedling establishment was less successful on litter. All shade tolerant species were able to successfully establish in areas of dense herb and shrub covers, albeit at rates lower than when herbs and shrubs were absent. The results suggest that green tree retention may be an effective management strategy for increasing the conifer component of riparian areas.

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## **The distribution of conifers and red alder in riparian zones: Role of soils and other factors**

Kerri Mikkelsen  
Robert Edmonds

Riparian old growth forests bordering second and third order streams were historically dominated by conifers in lowland western Washington. After extensive cutting, many of these systems became dominated by red alder (*Alnus rubra*). There is considerable interest in converting alder dominated riparian systems to more "natural" conifer stands. The methodology for conversion, however, is still being developed. This study in Browns and LeBar Creeks, tributaries of the Skokomish River Basin in the Olympic National Forest, will explore what factors promote the establishment, growth, and survival of conifer species in riparian forests. Specific objectives are to (1) Determine if soil parameters differ under red alder and conifer stands in

riparian forests; (2) Define the role of coarse woody debris (CWD) in conifer establishment in riparian forests and determine if a relationship between landform and conifer survival exists; (3) Determine what factors are correlated with western red cedar seedling survival and growth 5 years after being planted in girdled red alder stands; and (4) Determine what factors promote survival and growth of red cedar under controlled greenhouse conditions. This study will measure tree size, age, and spatial distribution; function of CWD within the landscape; soil pH, organic matter, moisture, nitrogen, phosphorus, texture, and microbial biomass; flood frequency and extent, and concentrations of stream nitrogen. Preliminary results in alder girdled stands indicate that conifer survival is greater on terraces than on wetter floodplain soils. Soil pH is not significantly different under conifer and alder stands. Alder adds significant amounts of nitrogen to streams during the fall. Management strategies will be developed from study results.

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## **The role of red alder in streams: Time to allow the villain back into the fold?**

Rick Edwards  
Robert Edmonds  
Peter Kiffney

Many current riparian rehabilitation programs stress elimination of hardwoods, especially red alder (*Alnus rubra*), and regeneration of various conifer species. Recognition of the critical role large woody debris plays in sediment retention and habitat formation has led to an emphasis on reestablishment of conifers to increase recruitment of large, strong and decay-resistant wood in to stream ecosystems. Past logging practices have resulted in large areas of dense red alder growth in areas where cedar, spruce or hemlock once grew. Alder wood is smaller and is thought to decompose rapidly, therefore its value in forming stable stream structures is questionable. Recent research on the role of red alder in stream ecosystems requires that we reassess our attitudes toward this valuable and natural component of Northwest ecosystems.

Rivers in less developed watersheds within the Pacific Northwest tend to have low concentrations of essential plant nutrients, especially nitrogen, and are therefore less productive than similar rivers in other locations. In salmon bearing rivers, historic runs of large numbers of spawners brought large amounts of marine-derived nutrients back to natal streams, fertilizing them and increasing the production of algae, invertebrates and fish. However, reductions in run size due to overharvest, habitat loss or other factors have reduced inputs of critical nutrients reducing stream productivity. In lower reaches of Northwest rivers, alluvial floodplains have historically been dominated by red alder, a pioneering nitrogen-fixing species that builds large pools of soil nutrients over its 70-100 year life span. Recent research in floodplain rivers has shown that subsurface water movements transfer nitrogen from riparian alder forests to adjacent aquatic habitats creating 'hotspots' of productivity where upwelling nutrient-laden water enters the stream. Although replacement of alder with conifers in upland streams is undoubtedly desir-

able, thought should be given to maintaining some proportion of alder as a management technique to enhance stream production. This could be especially useful in streams where salmon runs have been reduced or eliminated. New research shows that decay rates of alder-derived LWD are not significantly faster than conifers under submerged conditions, so alder may provide benefits both dead and alive.

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## **The 303 (d) list: Are Eastern Washington's streams in hot water?**

Jenna Scholz

The effects of increased stream temperatures on salmonids, trout, and other aquatic/riparian species is the current focus of many state and Federal agencies. Several regulatory measures have been promulgated to mitigate impacts of increased water temperatures on aquatic biota. Restoration activities have been initiated, conservation measures developed, and land use practices altered in an attempt to counteract a perceived yet undocumented increase in stream temperatures throughout Washington State.

Three of the five river systems draining the 2.20 million acre Wenatchee National Forest WNF have been placed on the Clean Water Act Section 303(d) list for non-attainment of the Washington State Department of Ecology standards for water temperature. A pilot study was conducted within managed and unmanaged river systems in this forest. Our objectives are to 1) use existing stream temperature data to identify spatial and temporal trends and patterns in stream temperatures across the entire forest and, 2) conduct a watershed-level comparison to identify basin characteristics and discriminate between temperatures arising from natural conditions from those affected by resource management activities.

We compiled existing water temperature data collected using continuous recording devices at more than 100 sites within the WNF from 1989-1998. These data were used to determine the variability in stream temperatures across the forest.

In 1998 and 1999, we conducted a stream temperature monitoring effort within 7 watersheds located throughout the WNF. Longitudinal temperature surveys were conducted from the headwaters to the mouth of each system. Profiles included water and air temperature monitoring as well as site-specific collection of canopy closure, drainage area, flow, and elevation data. This information will be used to evaluate differences in stream temperature conditions from similar watersheds with different management histories.

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## Regional, synchronous field determination of summertime stream temperatures in Western Washington

Derek Booth

The determinants of stream temperature are relatively well understood in the abstract, but their quantification in any given watershed is confounded by the vagaries of groundwater and surface-water inflows and the complex interplay of stream orientation and sun angle, canopy cover, and air temperature. For the second year running, the Center for Urban Water Resources Management (CUWRM), with cooperation from the Center for Streamside Studies and local stormwater agencies, tribes, and citizen groups, coordinated a regional, one-day intensive stream-temperature monitoring survey (August 4<sup>th</sup>, 3-5 PM). Sites were arrayed to provide system-wide coverage, with watershed areas ranging from 100 km<sup>2</sup> on down to the limits of perennial flow. Reflecting our interest in quantifying human influences, we targeted watersheds with primarily urban and suburban land uses but included some rural and forested basins as controls.

Over 100 individuals collected over 700 temperature measurements across the south-central Puget Lowland in this two-hour period. CUWRM made field forms, established protocols for the temperature measurements, and defined routes for the individual volunteers.

The air temperature that day (27 °C) was significantly hotter than the month's average (23 °C) and only slightly cooler than the maximum for the month (28 °C; the warmest day in 1999 was 30.5 °C on September 13). Our results are therefore representative of the near- (but not absolute) maximum conditions. Measured water temperatures in 1999 ranged from 9 to 27.5 °C (1998's measured range was 9 to 25 °C); the average temperature across all stations was 16.5 °C in 1999 (15 °C in 1998).

A major focus of this year's investigation was to determine the reliability and replicability of these measurement techniques. Over 60 replicate measurements were made, by both the same individual (at different times in the 2-hour period) and by different individuals visiting the same spot (also at different times, generally). Nearly all of the paired measurements are within about 0.5 degrees of each other. There is no trend to the temperature measurements across the two-hour period.

In general, "rural" streams are only slightly cooler, as a group, than suburban and urban streams. The presence or absence of a riparian canopy exerts a clear influence on temperature (more canopy, cooler temperatures) and the incidences of extreme high temperatures virtually require a loss of shading.

The raw data for this study are posted on the Center for Urban Water Resources Management's web site (<http://depts.washington.edu/cuwrp/>) under "RESEARCH".

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## **Long term monitoring of riparian buffers using low altitude fixed-base aerial photography**

Richard Grotefendt

Detailed riparian stand composition inventories were conducted over 27 miles of streams in Alaska and Washington using a fixed-base large-scale aerial photography system. A dual, metric Rolleiflex 70mm, camera system mounted on a 12-m long boom and carried by a helicopter was used to take the pictures. Imagery at scales ranging from 1:2,000 to 1:6,000, respectively provided stereo coverage ranging from 0.90 to 8.12 hectares. Measurements of riparian stand variables and channel characteristics were made from the photographs using the AP190 analytical stereoplotter. This instrumentation and camera system yielded horizontal errors ranging from 0.20 % to 1.76% and vertical errors ranging from 1.16% to 2.61%.

Digitized data were entered into a geographic information system to facilitate archival or computation of the following variables: (1) standing tree, down tree, and stump locations and counts; (2) horizontal distances to stream from standing trees, down trees, and stumps; (3) type of standing trees (conifer, deciduous, snag, or species); (4) height of standing trees; (5) length of down trees; (6) down tree direction of fall; (7) down tree decay class; (8) down tree landing spot; (9) logging debris position and length; (10) roads; (11) channel area; (12) length of reach; (13) area of stereo coverage; and (14) minimum and maximum horizontal distances from the channel edge to timber harvest boundary and stereo coverage boundary. These data were used to evaluate buffer zone characteristics and to measure their effectiveness for supplying woody debris to streams.

For long term monitoring, ground control was later collected in the field from natural targets identifiable on our 1:2,000 and 1:6,000 imagery and supplemental 1:60,000 U.S.D.A. Forest Service imagery. Bridging of this ground control and a 2-D conformal coordinate transformation allowed all the riparian stand composition inventory data to be referenced to the local state plane geographic coordinate system with root-mean-square (RMS) errors of 0.95 m easting and 1.11m northing. The high resolution imagery provided an efficient method for evaluating buffer zones, a baseline for future studies, and a long term record that enables repeated investigations.

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## **A comparison of methods for measuring water clarity**

Ashley Steel

Riverine water clarity is a key determinant of benthic community ecology and fish behavior; yet, measuring water clarity in shallow streams or fast-flowing rivers can be difficult. Vertical Secchi discs are often impractical and electronic methods have been criticized for their lack of accuracy. The horizontal black disc was introduced as a method for accurately measur-

ing the inherent optical properties of water. It can be easily employed in streams and rivers. This study collected many measurements under variable field conditions in order to compare measurements between the horizontal black disc and two more traditional measures of water clarity: a vertical Secchi disc and an electronic nephelometer. A fourth technique, the horizontal Secchi disc, is introduced to isolate the effect of measurement orientation (horizontal or vertical) versus the effect of disc color in comparing the visual discs. Results indicate that the horizontal black disc provides a consistent measure of visibility that is strongly correlated with both the vertical ( $r = 0.96$ ) and horizontal Secchi discs ( $r = 0.98$ ). Correlation between the visual discs and the electronic nephelometer was high ( $-0.8601 < r < -0.8489$ ) but not as high as correlation between the three types of visual disc. The estimated coefficient of variation, an indicator of potential measurement error, was similar for the three visual methods but higher for the electronic nephelometer. Further analysis indicates that there is some inter-observer variation in horizontal disc readings and that weather conditions, for example rain, may effect the horizontal black disc readings.

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## **Patterns of gravel entrainment in Puget Lowland, Washington streams**

Christopher Konrad

The stability of stream bed material influences a variety of biological conditions of streams ranging from periphyton biomass to the taxonomic diversity of benthic communities. Whereas stream bed stability can be assessed using sediment transport analyses that have been developed for engineering and geomorphic applications, these analyses do not address ecologically relevant characteristics such as the frequency of bed disturbance or area of stream bed likely to be disturbed during a flood. Results of field experiments using “bed tags” in three Puget Lowland, Washington streams show an approximately linear relationship between the spatial extent of gravel bar disturbed during floods and the peak reach-average shear stress scaled by the median particle size of surface material. Observations of bed tags also reveal intra-reach patterns and stochastic changes in the threshold of gravel entrainment, which may be important considerations for assessing stream bed stability over longer reaches and time scales.

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# Debris flows and salmon habitat in coastal Oregon and Washington

Dave Montgomery  
Tamara M. Massong, Tim B. Abbe,  
Suzanne C. S. Hawley, and Tim Schaub,

Field surveys in six channel systems in the Oregon and Washington Coast Ranges reveal systematic differences in the type and location of log jams and the associated influences on salmon habitat between channels flowing through mature and industrial forests. In the mature forests that we surveyed, log jams anchored by large key member logs were distributed throughout the channel network, and debris-flow-formed jams account for only 3% of all log jams surveyed. In contrast, almost 20% of the log jams found in industrial forests were deposited by debris flows, and most of these jams were located at tributary junctions. In the surveyed channels flowing through both mature and industrial forests, the distribution of bedrock and free-formed alluvial channels generally conforms to an inverse drainage area-slope threshold, although both the specific threshold and the relative influence of log jams, boulders and local variations in sediment supply differs among watersheds. Comprehensive longitudinal field surveys in the three coastal Oregon watersheds show that pools formed by the direct and indirect effects of debris flows account for 4 to 6% of all pools in reaches surveyed. Logs and log jams accounted for half of the pools formed in surveyed reaches flowing through mature forests but only 12% of pools in reaches flowing through industrial forests. In contrast, bedrock pools accounted for twice the percentage of pools in industrial forests than in mature forests. Field data on the size of snapped and standing trees impacted by debris flows support a simple model for the size of a log that can resist breakage by debris flows. Analyses of additional data from field surveys conducted by the Oregon Department of Forestry supports the inference that debris flow runout distances are greater in clear cut and young forests than in >200 year old forests. Together these data imply that log jams anchored by large key member logs retard debris flow propagation through mountain channel networks in mature forests. Based on our field observations we propose a three zone process-domain model for controls on both bedrock and alluvial channel distributions and the general effects of debris flows on salmon habitat. We find that sediment impoundment and local scour associated with log jams can locally enhance habitat suitability for salmon in both mature and industrial forests, but there is a substantial difference in the relative importance of debris-flow-formed habitat in mature and industrial forests.

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## **Land-use effects on suspended sediment in Puget Lowland salmonid streams**

James Packman  
Susan Bolton

The presence of suspended sediment and other solids in the aquatic environment is sensitive to upstream land-use and largely determined by the source and pathway of sediment input. Once in a stream, suspended solids can have a wide range of deleterious effects on salmonids depending on concentration and composition of particles as well as duration of exposure to fish. We are collecting storm event samples from low to moderate gradient salmonid streams in the Puget lowlands with single primary land-use: three urban streams, two agricultural streams and three forest streams. We hypothesize that there are differences in the concentrations, composition (organic/inorganic and particulate/dissolved) and particle sizes of total suspended solids (TSS) and total dissolved solids (TDS) among streams under different land-use. Such information is valuable in determining how different land-use affects the input of fine sediment and other solids into the aquatic environment. This may indicate potential causes of salmon decline due to anthropogenic effects on sediment in streams. We are also exploring using turbidity as a surrogate TSS measurement. Initial results indicate distinct trends between TSS concentration and land-use, with urban streams showing the strongest correlation and forest streams showing the highest variability. Agricultural streams show the highest proportion of TDS while particle size and turbidity due to particulates correlates strongly with urban streams.

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## **Distribution and reactivity of dissolved organic matter in subsurface waters of a Pacific Northwest floodplain river**

Sandra Clinton  
Rick Edwards

Dissolved organic matter (DOM) availability to heterotrophic microorganisms affects biological production and nutrient fluxes in rivers. For bacteria living in the surface-groundwater mixing zone, allochthonous organic matter inputs are the primary control on these ecological interactions. Research has focused on surface-derived algal exudates fueling microbial activity along short (10s m) flowpaths while ignoring processes occurring along longer (1000s m) ones. In floodplain rivers, long subsurface flowpaths occur beneath productive riparian forests of various successional ages where advected DOM is rapidly used leaving downflow communities carbon limited. We have installed a system of wells and soil lysimeters across a floodplain terrace on the Queets River (WA) to determine if DOM from riparian soils is important in alleviating carbon limitation and stimulating microbial activity along hyporheic flowpaths. Ini-

tial measurements indicate that DOM is low and variable in this system (0.01-3.00 mg/l). Hyporheic DOM concentrations increase from sites of bare cobble and young alder to sites of old alder and mixed conifer old growth. Soil water DOM concentrations are up to 10 fold higher than adjacent subsurface waters. During 12 hours of a storm DOM concentrations did not vary in lysimeters and wells while nitrate-N was rapidly leached from the soil column, suggesting that nitrate-N and DOM leaching are decoupled. We need to understand the sources and timing of DOM inputs in these systems to determine controls on subsurface production and nutrient cycling.

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## **Nutrient dynamics in an Alaskan stream: What role do salmon play?**

Tom O'Keefe  
Rick Edwards

Anadromous salmonids returning to their natal streams make significant contributions of marine-derived nutrients to the aquatic ecosystem. Recent evidence from stable isotope studies suggests that these returning fish may also fertilize riparian vegetation. Our objective was to determine if hyporheic pathways are a significant vector for transfer of marine-derived nutrients to riparian vegetation. Results from Lynx Creek, a small stream in southwest Alaska with an annual sockeye salmon run, demonstrate that hyporheic flows are capable of delivering nutrients from the stream to riparian vegetation. Values for nitrogen and phosphorus, however, followed hydrology and showed no obvious pattern with respect to the return of salmon in August. A flux budget for nitrogen revealed that salmon provide approximately 4% of the annual nitrogen discharge. Geomorphology may be a more important factor than presence of salmon for nitrogen chemistry as the highest values for dissolved nitrogen in the drainage corresponded to the high-gradient streams draining alder slopes. A budget for phosphorus, however, revealed that inputs from salmon were 123% of annual discharge. Our results indicate that the nitrogen supplied by fish is low relative to influx from alder slopes, but phosphorus inputs from fish are relatively high.

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## **Body size, arrival date and reproductive success of pink salmon, *Oncorhynchus gorbuscha***

Bobette Dickerson  
Thomas Quinn and Mary Willson

Many factors affect the reproductive success of individuals, including primary factors related to the number of progeny at fertilization (fecundity for females and breeding opportunities

for males), secondary factors related to the likelihood of survival of the offspring (egg size, nest site quality and duration of guarding), and tertiary factors that are important in that they affect the primary and secondary factors (body size, secondary sexual characteristics, breeding date, vulnerability to predation). Each of these factors is part of a complex mosaic of tradeoffs and interactions that ultimately determine the reproductive success of an individual. This mosaic was investigated in pink salmon, (*Oncorhynchus gorbuscha*), during the 1997 and 1998 breeding seasons in a naturally reproducing population in southeast Alaska, with emphasis on the relative influences of body size and arrival date on the other traits. In females, the results revealed strong positive relationships between body size and both fecundity and egg size, but no relationships with in-stream longevity, predation vulnerability, or nesting habitat. In males, body size and shape did not influence in-stream longevity or predation vulnerability but did influence dominance. In both sexes, arrival date was associated with longevity (early arrivals lived longer) but co-varied with fish length in opposite ways in the two years (large fish tended to arrive later than small ones in 1997 and earlier in 1998). In 1997, the early-arriving males were more often dominant than the later arrivals despite the fact that the early fish were smaller. Taken together, the results indicated that both body size and especially arrival date affect potential reproductive success but that complex interactions between these factors and trade-offs between other factors (e.g., egg size and fecundity) are also very important.

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## **Consumption choice by bears feeding on salmon**

Scott Gende

Consumption choice by bears feeding on salmon was recorded for over 20,000 bear-killed fish from 1994-1999 in Bristol Bay (sockeye salmon) and southeastern Alaska (pink and chum salmon). These data revealed striking patterns of partial and selective consumption that varied with relative availability and attributes of each fish. As the availability of salmon decreased, bears consumed a larger proportion of each fish both within habitats among years and within years among habitats. When availability was high (absolute number and density of salmon), bears selectively consumed salmon according to their spawning status and sex, targeting fish or body parts higher in energy. Ripe fish were consumed to a much greater extent than spawned-out fish for both sexes. Controlling for spawning status, the proportion of biomass consumed per fish was similar for males and females but bears targeted different body parts; the body flesh, brain and dorsal hump in males and the roe in females. Bears appear to maximize energy intake by modifying the amount and body parts consumed based on availability and attributes of spawning salmon.

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## **Understanding diversity among participants in the Copper River Personal Use Fishery**

Amber Kocsis

The Copper River Personal Use (CRPU) Fishery is a dipnet salmon fishery located near Chitina, Alaska. The personal use classification was created to give urban residents an opportunity to catch higher bag limits than they would in a sport fishery. In its evolution, this fishery has attracted a broad range of participants ranging from the fisherman in need of food to the fisherman in need of recreation. In recent years, the CRPU fishery has grown increasingly popular creating conflict with the neighboring sport, subsistence, and commercial fisheries and even environmental groups. With decreasing salmon populations, managers cannot make informed decisions regarding this fishery by only monitoring the biological component. This study will attempt to classify the needs and motivations of the users of this fishery. It would then be possible to make better judgements concerning the fishery.

Data will be collected using a mail survey. Some personal interviews will be conducted in addition to some participant observation. The research subjects will be drawn from the Alaska Department of Fish and Game permit holders list. Data from the mail survey will be analyzed using cluster analysis. From there, a typology of the users can be devised.

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## **Salmon and \$\$\$ in Washington State: Factors influencing the distribution of restoration dollars**

David Landsman

Due to the recent Endangered Species Act listing of many salmonid stocks throughout the state of Washington, much funding will be provided for stream restoration projects in the coming years. In 1998 and 1999 the Washington State Salmon Recovery Funding Board (SRFB) and related agencies distributed over \$17 million in grants for fish barrier removal, habitat restoration, and conservation easements. It is important to understand the effectiveness of this distribution process in order to improve future grant decision-making. Although scientists will not be able to measure success in terms of biological restoration for several years, there are other components of this distribution process that can currently be studied in terms of efficiency and effectiveness. My thesis will use two methods to study programmatic components of this restoration effort. One method will consider a sensitivity analysis of whether restoration projects were selected according to a robust formula. Another method will survey the grant applicants (for both funded and not-funded projects) of three different grant programs and determine their perception of efficiency and equity in decision making. I will provide background of the SRFB

distribution process, some initial analysis of how the political process may not necessarily meet biological need, and the framework for the remainder of my thesis study.

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## **Geomorphic effects of log jams in large rivers: Past and present**

Tim Abbe

Human alteration of the landscape may be responsible for present day perceptions that wood debris plays a relatively minor role in the morphology of large rivers (> 50 m wide). Field surveys of the Queets River in Olympic National Park demonstrate that in-stream wood debris accumulations or log jams are a principal factor affecting not only channel morphology, but also the development of the floodplain and terraces. Log jams within the mainstem Queets River are responsible for forming the deepest pools and half the total number of pools observed. Over ninety percent of the islands along the mainstem Queets (between 1985-1993) were associated with log jams, resulting in a distinctive anastomosing channel planform. Log jams can further affect channel planform by reducing the radius of curvature as much as 10 times, a process which contributes to channel avulsions and island formation. Within the floodplain of the Queets River, log jams offer sites of forest refugia that allow development of patches of old growth despite repeated assault by a channel that can migrate across its floodplain in several decades. Radiocarbon and tree ring dating indicate that buried jams can last over 1000 years. But perhaps most significantly, log jams affect floodplain and terrace development. Periodically, log jams attain proportions sufficient to impound the entire river, elevating the channel and floodplain 8 meters or more. As the river finds a new way around these obstructions, incision results in alluvial surfaces resembling terraces. Observations from the Queets basin may not be unique; examples of channel spanning log jams have been found in the Yakima, Tye, South Fork Stillaguamish, and lower Nisqually Rivers in Washington State. Historical records provide additional evidence that log jams influenced floodplain development from the Pacific Northwest to the southeastern United States, and removal of these log jams has led to incision with irreversible valley-scale effects. In the Queets Valley terrace-like landforms continue to form and be "re-activated" and represent the magnitude of floodplain relief which can be attained simply due to wood loading, creating tiered floodplains uniquely representative of forested land.

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## **E**cological risk assessment: **S**tatus of the science

Jody Brauner

The pursuit of clean water, clean air, and endangered species protection has received nationwide interest during the late 20th century. As impacts to our natural resources continue to grow, the need to understand streams as ecological systems and to manage them effectively has become increasingly important. Relying on tools developed in other fields (i.e. military strategy, automobile fatality, flood, and nuclear accidents), state and federal regulatory agencies have embraced the concepts of risk assessment in environmental decision-making. The challenge now lies in the implementation of ecological risk assessment.

Current regulatory guidance provides a broad-based framework in which to assess risk. However, the specific tools and techniques are still under development. In order to successfully conduct an ecological risk assessment, resource managers require expertise in multiple fields such as the physical and biological sciences, statistics, modeling, and policy.

This talk will provide an overview of the current status of ecological risk assessment, with a focus on conflicting perspectives, concerns and future opportunities.

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## **A** comparison of the hydraulic of large woody debris and an engineered wood alternative

Anne Watts Savery  
Susan Bolton

This pilot study compares the hydraulic effects of placing native large woody debris (LWD) or an organic, engineered alternative to large woody debris (ELWd™) as individual structures in lowland streams of Washington State. The engineered structures consist of an interlocking complex of small diameter poles that can be carried by hand and assembled on site. Like LWD, ELWd™ has a high hydraulic and surface roughness to trap sediment and debris. Unlike large woody debris, ELWd™ structures are hollow, weigh less and have a convoluted surface.

Pairs of ELWd™ and LWD logs (7.3 m long, 60 cm diameter) were placed to compare the interaction of the two wood components with the substrate of plane bed reaches. The log pairs were placed in randomized order in similar local hydraulic conditions. Pairs were placed 30 meters apart to minimize interaction between the wood components. All pieces were angled downstream 35-40° from perpendicular to the bank. The logs were positioned with the rootwad on the bank with one-third of the length on the bank and the remainder of the length within the bankfull channel. All pieces were loosely tethered (10 meters of slack) with 1.3 cm galvanized steel wire rope to nearby trees. Fire hose was wrapped around the tree bole to protect the living tree. The purpose of the loose tethering was to allow the river to place the logs where receding

waters left them, rather than to affix the logs in place. Additionally, 360 kilograms of rock ballast were added to the engineered structures to compensate for their light weight. Final weight of the structures was 1000 kilograms; a piece of natural wood weighs approximately 2000 kilograms.

The channel bottom was surveyed twice. The first survey of the channel bed took place before or just after placement of the wood structures into the streams (October 1998). The second year survey took place in July and August 1999. Surveys extended 3 meters up- and downstream of the logs in a 0.5m by 0.5m grid pattern. Volumetric change in substrate surrounding the logs will be calculated using the two years of data.

Wood components that maintained contact with the channel bed induced more scour than those that did not maintain contact. Overall, ELWd™ stayed in better contact with the stream bottom due to the decreased buoyancy as compared to native LWD. The native wood generally lifted off the bottom when high flows occurred. As a result, more scour occurred during high flows at the engineered structures than at the natural wood. The majority of scour associated with both the engineered structures and the natural wood took place at the tip of the log. Additionally, scour took place on the upstream side of some logs and directly under the log where the water was forced underneath.

ELWd™ is best suited for use in small stream systems (<6 cubic meters per second average maximum flow) that are lacking in woody debris. Although engineered structures are lightweight, they are comparable to natural wood in the ability to create areas of scour. The ballast and subsequent lack of buoyancy is an important factor to consider when installing ELWd™ in a habitat rehabilitation project. The ballast serves to make the hollow structure behave like a solid structure and may not be necessary in all applications of ELWd™. It is important to consider the flexibility and ease of use of the engineered structures as compared to natural large wood.

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## **A biological evaluation of stream rehabilitation: Comparison of the effects of large woody debris and an engineered alternative**

Jennifer O'Neal  
Tom Sibley

This is a pilot study to examine the biological effects of placing individual structures in two lowland streams of Washington State, Griffin Creek and the Mashell River. The test subjects are native large woody debris (LWD) and an organic, engineered alternative to large woody debris (ELWd™). The engineered structures consist of an interlocking complex of small diameter poles that form a single large diameter structure. Unlike LWD, these structures are hollow and have a larger surface area that is convoluted with gaps. The first objective of this study is to determine if there is a significant difference in the invertebrate and fish communities associated with ELWd™ and native large woody debris. The second objective is to determine the preferred invertebrate prey items for salmonids to develop a metric to evaluate invertebrate production.

Invertebrate sampling will consist of paired Surber samples from the adjacent benthos, and from the surfaces of the log structures. These will be compared using a paired t-test ( $\alpha = 0.10$ ) to determine if there is a significant difference between the communities associated with each structure. Fish population sampling will be conducted using electrofishing and snorkel surveys and compared using paired t-tests ( $\alpha = 0.10$ ) and graphical analysis. Preferential prey taxonomic groups will be determined by researching the current literature on wild coho diets in western Washington to determine which taxonomic groups will serve as the metric for evaluating the quality of food resources provided by LWD and ELWd™.

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## **Historic fire frequency comparisons between riparian zones and upslope forests in the Blue Mountains and Western Cascades of Oregon**

Diana Olson  
James Agee

This study compares the historic fire frequency within a riparian zone to the fire frequency occurring in the adjacent upslope forest. It covers portions of three national forests within two distinct geographical locations: the Blue Mountains of eastern Oregon and the western slope of the Cascades in central Oregon. During the summers of 1997 and 1998, 430 fire scar wedges were collected from 67 one hectare plots. In the Blue Mountains, fire scar samples were collected from plots in the vicinity of the Dugout Creek Research Natural Area of the Malheur National Forest and the Baker City watershed of the Wallowa-Whitman National Forest. All plots were adjacent to upslope plots sampled by Emily Heyerdahl, University of Washington, in 1995. In the Cascades, fire scar samples were collected from both riparian and upslope plots within the Upper Steamboat watershed of the Umpqua National Forest. In all three areas, sampling was divided between small-sized streams and medium-sized streams. Samples are still being processed, but preliminary results for the Malheur National Forest study area (which consists primarily of ponderosa plant associations) suggest there is no difference in fire frequency between riparian and upslope plots, for either size stream, and there is no difference in fire frequency between small-sized stream and medium-sized stream riparian plots. Preliminary results for the other two study areas are not yet available.

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# posters

## **Summer temperatures in small timberland stream sources on the Western Olympic Peninsula**

Jenelle Black

Temperatures at the sources of 23 streams were monitored through the peak temperature period of 1997. Differences between marsh-sources and spring-sources were found in temperatures and in responses to harvest/shade conditions around the sources. In general marsh sources were warmer than spring sources and were also more affected by timber harvest. These differences imply that forest managers trying to protect small streams with harvest buffers may not need to provide as extensive protection around spring sources as they may around marsh sources to protect amphibian habitat.

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## **Controls on hyporheic invertebrate biodiversity and community structure on the Queets River, Olympic Peninsula, WA**

Holly Coe  
Rick Edwards

Riparian hyporheic zones have recently been recognized as an important part of the hydrologic continuum, effectively linking terrestrial, surface and subsurface components of rivers. The hyporheic zone is an area of saturated sediments located beneath and adjacent to streams and rivers and containing at least some surface water. The dynamic, ecotonal nature of this zone promotes considerable invertebrate and microbial production. Microbes mediate intense biogeochemical processing affecting nutrient cycling and retention, and, in some cases, profoundly influencing surface water chemistry. Surface/hyporheic interactions are further influenced by the abundance and diversity of hyporheic invertebrates, which control microbial biomass and production through grazing, ultimately moderating the effects of nutrient cycling and retention on surface waters.

The primary goal of this project is to identify the spatial and temporal dynamics of hyporheic invertebrate community structure in an alluvial floodplain river. Specifically, this study seeks to determine patterns in hyporheic invertebrate biodiversity and community structure in relation to hydrology, and physical and biological parameters. Samples of invertebrates and organic matter along with dissolved oxygen, temperature, and electrical conductivity data are being collected seasonally from a total of 55 wells installed on a floodplain terrace on the Queets River, WA.

Preliminary results indicate the presence of at least 12 major taxa including archiannelids, amphipods, chironomids, copepods, hydrachnids and tardigrades. Invertebrate diversity and abundance differ greatly among wells. Organic matter and measured physical parameters also differ among wells and between seasons. Hyporheic invertebrate communities provide unique insights into the linkage among terrestrial, surface and subsurface components of rivers and may ultimately play an important role as indicators of water quality and ecosystem health.

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## **Collaborative design of fish habitat enhancement projects in streams and rivers of Washington State**

James Dooley

A study was conducted of project-level design processes related to fish habitat enhancement projects across Washington state. Data were collected from 65 projects within 12 Water Resource Inventory Areas. Over 200 individuals and agencies were found to have participated in project-level decision making. Social network analysis was used to identify communication linkages between participants, and to identify likely sources of influence. Social networks were weak within and across projects, except in rural eastern Washington. Problem framing by sponsors and participants had a substantial influence on objectives and constraints, but little impact on chosen solution features. Team structure appeared to take on the form of an informal collaborative network rather than a formal organizational structure. Engineers played various roles including analyst, designer, advisor and leader. Engineering roles were highly situational and not predictable from project to project.

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## **In-stream wood in old-growth forest drainages: A characterization considering geomorphic variation**

Martin Fox

To characterize the spatial distribution, orientation, size, quantity, and other characteristics typical of wood found in streams draining old-growth forests of the Pacific Northwest, surveys were conducted in over 90 stream segments within National Parks and Wilderness areas within Washington State. Survey sites were selected to represent a wide array of geomorphic channel types found within the State of Washington, and were identified by gradient, confinement, stream width, geology, roughness, bed morphology, origin, and eco-region. Channels were also evaluated in accordance to the channel classification method of Montgomery and Buffington (1997).

All wood with midpoint diameter  $\geq 10$  cm and two meters in length were measured and assessed for decay, channel position, orientation, stability, and species. Stem density, diameter, height and species distribution surveys in the adjacent forest were conducted to assess the riparian character of these drainages.

Because wood is recognized as an important feature linked to channel processes that benefit salmonids, and because stream channel assessments often associate the size, distribution, and abundance of woody debris to salmon habitat quality, target wood values will be developed to assist resource managers evaluate and manage streams. Current evaluation methods for wood seldom account for geomorphic variability and are subsequently inaccurate for some streams. Because resource managers frequently rely upon standardized wood targets for multiple channel types when making decisions, a great need exists to refine current methods to more accurately account for natural variation among these channel types. Assuming salmonids have evolved to wood loading/channel disturbance rates of pre-management conditions, the average structure of these streams could be interpreted as having favorable habitat. Therefore, the mean quantity, size, and distribution of wood found in unmanaged systems may provide an indicator to the general "health" of a stream. This study will refine the current wood diagnostics or target criteria, and establish a basis for defining key parameters of wood quantity and quality in a stream based on the historical range of conditions given natural disturbance regimes. Ultimately a channel classification system incorporating patterns of variability in the data will be developed that identifies appropriate wood loading targets applicable to resource management. These target conditions can help guide resource management for stream assessment, restoration, and enhancement projects that benefit salmonids.

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## **Fertilization of riparian vegetation by spawning salmon: Effects on tree growth and implications for system productivity**

Jim Helfield  
Robert Naiman

Anadromous Pacific salmon (*Oncorhynchus* spp.) transport marine-derived nitrogen (MDN) to the rivers in which they reproduce. Isotopic analyses indicate that riparian trees and shrubs near spawning streams derive approximately 22 - 25% of their foliar nitrogen from marine sources. Growth rates are enhanced in Sitka spruce (*Picea sitchensis*) receiving MDN inputs, resulting in significantly larger trees near spawning streams. The overall effect is increased shading, bank stabilization and large woody debris (LWD) production, resulting in enhanced instream habitat for juvenile salmon. These findings suggest that spawning populations of salmon

stocks maintain the long-term productivity of river and riparian systems along the Pacific coast of North America.

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## **Evaluating the performance of a pilot-scale constructed wetland treating municipal effluent: A three angled approach.**

Lenore Jensen  
Kurt Marx and Margaret McCauley

In 1993, the City of Stanwood, Washington, constructed a wetland in an unused lagoon of the already-existing wastewater treatment plant. The purpose was to assess the plausibility of using such a system to augment wastewater treatment, in the face of continuing population growth. In 1998, two graduate students from the University of Washington Department of Civil and Environmental Engineering began conducting studies on various aspects of the wetland's performance. Kurt Marx examined the effects of loading rates on water quality, while Margaret McCauley examined the treatment capabilities of three different plant species. A third graduate student, Lenore Jensen, has begun investigations into the effects of varying amounts of plant cover on treatment performance. It is believed that these three angles of investigation will culminate in a well-rounded and comprehensive study of Stanwood's pilot scale project, and will result in appropriate recommendations to the City of Stanwood.

The results and ensuing action by the City are important because the facility discharges directly into the Stillaguamish River. The monitored water quality parameters—biochemical oxygen demand (BOD), total suspended solids (TSS), nutrient levels (NH<sub>4</sub>-N, NO<sub>x</sub>-N, and TP), dissolved oxygen levels, temperature, and pH, have direct consequences to the receiving body of water. For example, elevated nutrient levels can lead to eutrophication and subsequent loss of oxygen, which has ramifications for all life forms in the river. In this wetland, nutrient removal is primarily a function of loading rate, retention time, and temperature, with the lowest loading rates, and the highest detention times and temperatures lending to higher performance rates. There were no strong treatment differences among the three species of plants examined (*Schoenoplectus acutus*, a specified species, and *Phalaris arundinacea* and *Typha latifolia*, two species that have invaded and are now pervasive in the wetland). Preliminary results from the work of Jensen show that the wetland is still adjusting to the changes in season and to the re-engineering of its accustomed loading rates.

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## **A comparison of historic and current riparian forest condition in Eastern Washington and effects on stream temperature**

Gardner Johnston

Riparian management is an important issue in eastern Washington forests where many streams have recently been placed on the state's 303(d) list for exceedance of water temperature standards. An understanding of historic and current conditions acting on these systems is necessary to assist forest managers and regulators in making appropriate management decisions. Our objective is to identify the historic conditions of eastern Washington riparian areas and compare these findings with the condition of currently managed systems. Specifically, we plan to focus on factors affecting stream temperature. Characteristics to be measured include percent canopy cover, tree species composition, stand densities, forest health (i.e. disease and fire susceptibility), and stream temperature. The historic fire regime will be characterized due to its important effect on these factors. Aerial photos, survey records, field investigations, and reference sites will be used to reconstruct historical conditions. An empirical temperature prediction model will then be used to compare historic and current systems.

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## **Wood distribution in unmanaged streams: A diagnostic approach based on geomorphic variation**

Emily Lang  
Loveday Conquest

The purpose of this project is to establish reference information for wood quantity, spatial distribution, and volume in streams draining old-growth forest basins. This information will be used to establish target value to what we should expect to see within a given channel type, and how we should model wood restoration projects in the future.

Over the duration of three months, we surveyed over five miles of stream in areas from Mt. Rainier National park to Eastern Washington. The streams we surveyed varied greatly in depth, width, grade, channel type and discharge. In the streams, we measured near twenty-five hundred pieces of large woody debris.

We observed that the amount and size of LWD in a given stream is related more to the riparian zone around the stream than it is to the stream characteristics. However, wood position, decay class, stability and small woody debris are related to stream characteristics. In deeper

streams with higher discharge, the wood tended to be less decayed and oriented parallel to the stream bank. In streams with lower discharge wood was often oriented askew to the river flow.

The results of this research are presently being compiled by graduate student Martin Fox.

Emily Lang (See Martin Fox's contact information)

## **E ffects of timber harvest activities on the distribution and genetic heterozygosity of coastal Cutthroat T rout**

Joshua Latterell

Fish distribution is an important criterion in the management of riparian forests in Washington. A logistic regression model based on remotely-sensed drainage characteristics has been shown to accurately predict the upstream extent of fish distribution in streams draining land managed for timber harvest. Allopatric coastal cutthroat trout *Oncorhynchus clarki clarki* typically represent the upstream extent of fish distribution in the Pacific Northwest. Since timber harvest activities may alter stream habitat characteristics related to cutthroat distribution, model predictions may not be representative of native conditions. Timber harvest activities may also modify the genetic heterozygosity, and possibly the long-term population viability of cutthroat in headwater streams. Genetic heterozygosity is sensitive to effective population size and population stability, both of which may be altered by activities associated with timber harvest and production. This research will 1) determine whether similar interactions of stream-scale physical habitat parameters limit the upstream extent of cutthroat distribution in streams draining unmanaged forests (wilderness streams) and land managed for timber production (managed streams) and 2) determine whether genetic heterozygosity differs between managed and wilderness streams.

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## **A preliminary examination of the controls on small headwater channel morphology and habitat influence in managed forests**

Mike Liquori

Many assumptions regarding small headwater channels have resulted in regulatory constraints that may act to homogenize the riparian areas around small headwater channels. Basic understanding of small headwater channels is often driven by extrapolation of research done on larger channels. Preliminary data analysis suggests that common assumptions may NOT accurately reflect how these systems behave. Thresholds may exist for various riparian functions (e.g. LWD function), many of which may be expressed in how some small streams respond to

the functions, while others do not. An on-going study of small streams (e.g. <10 ft wide) and their relationship to geomorphic variables has resulted in data for 154 miles of small streams in primarily second growth, managed forests in Pierce and Lewis Counties, Washington. Stream surveys include both extensive and intensive data, and offers insight into the behavior of small streams and their dependence on riparian functions. Some preliminary results suggest that:

- a) functional LWD size is a non-linear function of channel width
- b) increased LWD quantity does not increase the frequency of step elements relative to other factors
- c) morphologic classes exist over a significantly greater gradient range than larger streams
- d) micro-pool frequency is not related to LWD loading
- e) LWD loading thresholds are higher and less efficient in generating pools than is found in larger channel systems
- f) survey crew variability can significantly influence observed data patterns
- g) channel classes may control the influence of LWD on channel morphology

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## **Trophic relations between Coho Salmon carcasses, Oomycetes (water molds) and select Caddisfly larvae**

Graham MacKenzie

Anadromous salmonids are important vectors for the transfer of marine nutrients into freshwater and terrestrial ecosystems. The saprophytic Oomycetes (water molds) are critical intermediates in the transfer of these nutrients from the salmon carcass to caddisfly larvae. In the Pacific Northwest, the decay of salmon carcasses in some streams coincides with the later stages of development of several taxa of caddisfly larvae. These larvae accumulate energy reserves in the form of lipids and it is thought that marine derived nutrients are stored in this fashion.

A variety of methods were used to investigate the trophic relations between Coho salmon (*Oncorhynchus kisutch*) carcasses, Oomycetes and select caddisfly larvae. A growth experiment showed that *Onocosmoecus* sp. (*Limnephilidae*) larvae fed a diet of conditioned alder leaves supplemented with Oomycetes had higher instantaneous growth rates than larvae fed a diet of only leaves. Stable isotope studies showed that Oomycetes obtain most if not all their nutrients from salmon carcasses and that caddisfly larva in salmon bearing streams are enriched in these marine derived nutrients. Evidence of the direct consumption of Oomycetes by caddisfly larvae is provided through gut content analysis and photo-microscopy techniques. Preference tests reveal that after a three hour period caddisfly larvae prefer leaves to Oomycetes and to salmon meat. However, analysis of time-lapse videotapes recording these preference tests may reveal that preferences change over time. Ongoing work will determine if lipids extracted from caddisfly

larvae are storage sites for marine derived carbon. These lipids are important energy stores leading to successful metamorphosis and emergence of the adult insect.

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## **Long-term hydrologic record of a small watershed in the Hoh River Valley**

Georgia Murray  
Robert Edmonds  
Bill Baccus

Precipitation inputs, throughfall and streamflow have been monitored since 1985 in West Twin Creek watershed, in the Hoh River Valley, Olympic National Park. Precipitation data from 1969 - 1998 were obtained from the Hoh Ranger Station and the Quillayute Airport weather station. Stemflow and throughfall were measured from 1986-1991. Throughfall was collected using gutters that were beneath the canopy of a specific tree, while stemflow was collected using halved Tygon tubing that encircled the main stem. Throughfall was also measured from 1992 to 1998 using the 20-cm diameter polyethylene funnels with netted tops that drained into polyethylene collection bags. Data were compared between the two sampling intervals and methods. Continuous stage height was monitored at a V-notch sharp crested weir at the base of the watershed. Velocity was measured monthly and a rating curve was established. Rating curves were redone if large storms cause dramatic changes in the stream channel. Inputs and outputs are compared monthly and by water year.

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## **Center for Streamside Studies and U.S. Forest Service on-line stream riparian bibliography**

Barbara Nightingale

In an effort to better link field specialists and management with research resources, the U.S. Forest Service, Rocky Mountain Research Station, Stream Technology Center and the University of Washington, Center for Streamside Studies partnered to provide unique on-line access to an 11,000 citation bibliography for researchers, field specialists, and managers. Subjects covered include watershed management, riparian vegetation, fisheries, wetlands, fluvial geomorphology, and water resource law and policy.

The bibliography enables the user to search the entire database through a variety of paths such as author, title, publication date, periodical or keywords. Two modes of search are available: 1) a quick search tool for quick data retrieval limited to indexed field, and 2) an advanced

search tool for searching all fields indexed and non-indexed throughout the entire bibliography. Search matches provide bibliographic listing with the ability to mark and/or view the entire file associated with selected references. This often includes a publication abstract. The website is interactive, providing the user with the ability to export data to their own database and import data through the site's "Add Reference" form. On-line nationwide links to additional research tools, data and on-line publications are also provided. This on-line resource is unique in its ability to provide both field professionals and managers with extensive research information.

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